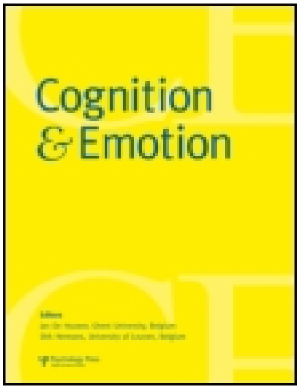

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Unintentional preparation of motor impulses after incidental perception of need-rewarding objects

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BRIEF REPORT

Unintentional preparation of motor impulses after incidental perception of need-rewarding objects

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Using a new method, we examined whether incidental perception of need-rewarding (positive) objects unintentionally prepares motor action. Participants who varied in their level of need for water were presented with glasses of water (and control objects) that were accompanied by go and no-go cues that required a response (key-press) or withholding a response. Importantly, if need-rewarding objects unintentionally prepare action, presentation of no-go cues should lead to motor inhibition of these prepared motor impulses. Consistent with this hypothesis, results showed that participants relatively high in need for water (and hence, who perceive water as a rewarding, positive object) were slower to react to a successive action probe after withholding a response during perception of water than during perception of the control object, suggesting motor inhibition of unintentionally prepared motor impulses. We propose that incidental perception of need-rewarding objects unintentionally potentiates preparation of motor action to these objects.

Keywords: Evaluation; Reward; Motor action; Inhibition; Impulse.

The relation between evaluation and action preparation receives continuing attention in behavioural science. One pervasive idea is that evaluation serves adaptive behaviour (e.g., Lang, 1995; Strack & Deutsch, 2004) such as capturing rewards and avoiding punishment. Accordingly, an important question is under what conditions perception of rewarding objects (e.g., a bottle of water when in need for water) prepares action in the motor system. In the present research, we tested a new method that relies on motor inhibition processes to examine whether incidental exposure to need-rewarding objects is sufficient to evoke a preparatory motor impulse, i.e., even when these stimuli do not require a response. Such a demonstration would extend previous work that has focused on preparation of responses toward or away from objects, and would suggest that mere

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perception of need-rewarding objects unintentionally prepares an individual for action and gaining the reward.

Previous work on the relation between evaluation and action preparation has often focused on preparation of specific approach and avoidance responses to affect-laden objects. For instance, Chen and Bargh (1999) have shown that participants are faster to pull a lever toward the body (an approach reaction) after perception of positive stimuli, and push a lever away from the body (an avoidance reaction) after perception of negative stimuli, than vice versa. This effect has not only been found for stimuli that are intrinsically positive (or negative), but also for objects that are rewarding because they can satisfy basic needs (Ferguson & Bargh, 2004; Seibt, Häfner, & Deutsch, 2007; Sherman, Rose, Koch, Presson, & Chassin, 2003). For instance, research has shown that as more time has passed since the last food intake (i.e., under conditions of relatively high need for food), perception of (rewarding) food objects elicits faster approach movements toward such objects compared to avoidance movements (Seibt et al., 2007).

Interestingly, recent research suggests that the approach–avoidance effect (e.g., Chen & Bargh, 1999) may not be a reflection of unintentionally evoked approach and avoidance responses per se, but is contingent on compatibility between valence of response codes on a cognitive, representational level and valence of stimuli (e.g., Eder & Rothermund, 2008; Lavender & Hommel, 2007). Specifically, responses are facilitated when valence of response codes (e.g., away = negative and toward = positive) and valence of stimuli match independent of specific muscle movements (Eder & Rothermund, 2008). It has been argued that this compatibility can even facilitate responses in single response tasks (e.g., Chen & Bargh, 1999; Experiment 2), as long as the valence of the response codes matches the valence of stimuli that require a response (Eder & Rothermund, 2008; Lavender & Hommel, 2007). Whereas this work does not rule out that perception of affect-laden objects can unintentionally prepare approach movements toward objects (Krieglmeyer, Deutsch, De Houwer, & De Raedt, 2010), it points to the difficulty of assessing unintentional preparation of motivational responses toward valenced stimuli.

In light of this debate, we aimed to assess unintentional motor preparation to positive (need-rewarding) objects with a new measurement procedure that does not assess approach and avoidance reactions toward objects (e.g., Chen & Bargh, 1999). Specifically, we examined whether incidental perception of need-rewarding objects (i.e., presenting the objects in a context where they do not require a response to get them) is sufficient to prepare responses to these objects, i.e., irrespective of the exact nature (e.g., spatial direction) of these responses. Hence, the present work is open to the possibility that this preparation concerns motivational (approach) responses, learned responses (e.g., idiosyncratic habits), or contextually cued responses (e.g., calling the waiter to order a glass of water upon seeing someone else drinking water on a hot day), as all these responses can increase the probability of attaining the reward. Importantly, instead of examining whether positive objects prepare some specific responses (e.g., approach movements) more strongly than others (e.g., withdrawal movements; e.g., Chen & Bargh, 1999), we are concerned with the question of whether incidental perception of positive (need-rewarding) objects unintentionally evokes stronger motor impulses compared to incidental perception of neutral (non-rewarding) objects (see also Hajcak et al., 2007).

In the current task, participants that differed in their need for water were presented with go and no-go cues, and were instructed to respond in line with these cues. Importantly, we displayed these cues over task-irrelevant glasses of water, or a control object. If perception of need-rewarding (positive) objects unintentionally increases preparation of responses to these objects, then more inhibition of these prepared motor impulses should be recruited when a no-go cue is displayed over rewarding objects than when a no-go cue it is displayed over a control (non-rewarding) object. In other words, perception of glasses of water should unintentionally prepare motor impulses when participants have a relative high need for fluid (but not when having a low need), and no-go cues should require them to inhibit this covert preparation to act.

Support for this reasoning stems from work in neuroscience that has revealed that presenting a no-go cue shortly after action preparation causes active inhibition of the motor system (Coxon, Stinear, & Byblow, 2006; see Aron, 2007, for an overview). This inhibition ensures that execution of any prepared motor programme is temporarily blocked or slowed down (Aron, 2007). Moreover, as action preparation becomes stronger, stronger inhibition is recruited on no-go trials to inhibit the prepared action (e.g., Picton et al., 2007; Veling & Aarts, 2009; Veling, Holland, & van Knippenberg, 2008). Thus, if need-rewarding objects unintentionally prepare for action, concurrent presentation of no-go cues should result in stronger inhibition of the motor system than when no-go cues are presented over a control object.

To assess this motor inhibition, we occasionally presented an action probe after presentation of the go and no-go cues (and concurrently presented objects), and instructed participants to react as quickly as possible to this probe. We will refer to these task response trials as *restart trials*. Reaction times to this action probe can serve as a measure of inhibition, because instigation of motor inhibition puts a brake on subsequent action (Aron, 2007; Coxon et al., 2006). Thus, if incidental perception of need-rewarding (positive) objects unintentionally enhances preparation of motor action, no-go cues should inhibit this motor preparation, resulting in subsequent slower restarting compared to when control objects are paired with no-go cues. We also measured reaction times on restart trials when they were preceded by need-rewarding or control objects with a go cue.

We believe that there are two aspects of this task that qualify any observed motor preparation by the need-rewarding objects as being unintentional. First, the need-rewarding objects (glasses of water for participants high in need for water) are irrelevant for performing the task, and never explicitly require a response. Second, as the need-rewarding objects are equally often paired with go cues and no-go cues, and equally often followed by cues requiring a response and withholding a response (see methods section), intentional (strategic) action preparation upon perception of these objects would not improve performance nor simplify the task. In fact, we predicted that action preparation evoked by the need-rewarding objects would result in a performance cost (i.e., slower responding on restart trials) when the objects were paired with no-go cues. Thus, intentional action preparation by perception of need-rewarding objects is, if anything, discouraged by the task demands. Finally, note that by measuring the indirect effect of action preparation after fixed presentation times of the objects (i.e., via motor inhibition of the prepared responses) the results are not very susceptible to differences in ease or speed of processing of the different kinds of objects (which can be the case in tasks were responses are made when the objects appear on screen).

In sum, we predicted that: if rewarding objects unintentionally prepare motor impulses more than (non-rewarding) control objects, more inhibition should be recruited when a no-go cue is presented over a glass of water then when it is presented over a control object for participants with a relatively high need of water. We expected to observe this motor inhibition in slowed reaction times to a subsequently presented action probe.

METHOD

Participants and design

The study included 53 undergraduates (36 females). Participants received €2 for their participation. We employed a 2 (Object Type: glass of water vs. control object) × 2 (Cue Type: go vs. no-go) repeated-measures design, and included need for water as a continuous factor.

Stimuli

For the go/no-go task we selected 12 pictures of glasses of water from the internet. These pictures varied somewhat in size, but were all around 200 by 200 pixels and were presented at a screen resolution of 800 by 600 pixels. Furthermore, we used a plain grey circle as control object (200 by 200 pixels).

Need measure

To assess the level of need for fluid, participants were asked to report how many minutes before the experimental session they had consumed fluid for the last time ($M = 73$ min; $SD = 70$; for a similar procedure see, e.g., Veltkamp, Aarts, & Custers, 2008a, 2008b). Previous research has found that the reward value (or positive valence) of a glass of water correlates positively with the time since last fluid consumption (Veltkamp et al., 2008a, 2008b). Thus, only participants that have a relatively high need for fluid represent a glass of water as a need-rewarding (positive) object. We log-transformed the need measure to reduce positive skew ($s < 1$), and used this standardised score as our measure of need for water.

Procedure

Participants received a modified version of a go/no-go task, and were asked to respond as accurately and quickly as possible to briefly presented cues that appeared on the computer screen in combination with other stimuli. They were presented with a glass of water or the control object for 500 ms in the middle of a computer screen. Either a go cue or a no-go cue was displayed 200 ms after object onset. The go/no-go cues were the letters “p” and “f”, which were presented for 300 ms. We counterbalanced the instructions (e.g., react to “p” and not to “f”) across participants. The go/no-go cues were displayed on the pictures in black font type (font size 12) on a white background, so that they were clearly visible. The go/no-go cues were presented in the middle of the pictures.

Immediately after each object–cue combination, one of three signs appeared in blue font type (i.e., a “?”, or a “*”, or a “ = ”). The signs were displayed in the centre of the computer screen for either 1000 ms, or until the participant responded. In the case of a “?”, participants were asked to respond in accordance with the cue (i.e., press the space bar with the index finger of the right hand after presentation of a go cue and refrain from responding after presentation of a no-go cue). These filler trials were included to ensure that the go and no-go cues became associated with responding and withholding a response. Importantly, participants were asked to always press the space bar when a “*” appeared instead of a “?”, i.e., even when a no-go cue had been displayed over the picture. Reaction times on these restart trials served as our dependent variable. In addition, when a “ = ” appeared participants were asked to always refrain from responding, i.e., even when a go cue had been displayed over a picture. These filler trials ensured that the probability of a no-go response was 50%. After a correct (non)response a green circle was presented, and after an erroneous (non)response a red cross was presented for 500 ms. The inter-trial interval was 500 ms.

To familiarise participants with the task they first performed a practice block involving all trial types. The actual go/no-go task consisted of 5 blocks of 24 trials. Within each block, each glass of water was presented once, and the control object was presented in the other 12 trials. In 50% of the trials a go cue was presented, and in 50% a no-go cue. Selection of a specific object and cue was random with the constraints that a specific object type (glass of water or control), and cue type (go or no-go) was not presented more than four times in a row, and that glasses of water and the control object were equally often paired with each cue type. After each picture–cue combination either a “?”, or “*”, or “ = ” appeared. The “?” was presented in 16 trials, the “*” in four trials and the “ = ”also in four trials. These signs were randomly selected with the constraints that, for each object type (glasses of water or control), every six trials consisted of four “?” signs, one “*” sign and one “ = ” sign, and that the “?”, “*”, and “ = ” signs were equally often paired with each cue type (go or no-go). In total, participants received 120 experimental trials, including 20 restart trials, 5 for each object type (glass of water or control)–cue type (go or no-go) combination.

Afterwards, participants were debriefed. Debriefing revealed that none of the participants were suspicious of the true nature of the study. In fact, most of them indicated that they tried to respond to the cues as was stressed by the experimental instructions.

RESULTS

Participants made few errors or omissions on the go/no-go task (3.3% collapsed over all trial types). Restart trials with responses that were faster than 300 ms (1.2%),[1] and omissions (i.e., exceeding the time—1000 ms—that the "*" remained on the screen) were removed (1.1%). We conducted analyses on log-transformed reaction times to reduce the impact of incidental slow responses, but analyses are also reliable when untransformed data are used. For clarity we present untransformed means. Sex of the participants did not affect the analyses.

To test whether more inhibition was recruited after presenting a no-go cue with a glass of water for those participants who had a relatively high need for water, we analysed response latencies on restart trials in the general linear model including the effects of Object Type (glass of water vs. control), Cue Type (go vs. no-go), Need for Water, and their interactions. First, this analysis yielded a main effect of Cue Type, $F(1, 51) = 44.47$, $p < .01$, $\eta_p^2 = .47$. Participants were slower to restart when trials were preceded by no-go cues ($M = 544$; $SD = 58$) than when they were preceded by go cues ($M = 494$; $SD = 58$). This finding merely reflects a switch cost when no-go cues preceded the restart signal. Importantly, and as predicted, the three-way interaction between Object Type, Cue Type, and Need was reliable, $F(1, 51) = 5.88, p < .05, \eta_p^2 = .10$. The effect of object type and the interaction between object type and cue type were not reliable, Fs < 1.

In order to examine the three-way interaction, spotlight analyses (Aiken & West, 1991) were used to examine the two two-way interactions between Object Type and Cue Type for participants with relative low Need (one standard deviation below the mean), and for participants with relative high Need (one standard deviation above the mean; i.e., by subtracting or adding 1 to the standardised score of need for water, thus shifting the mean higher or lower). The advantage of this procedure is that it allows for presenting and testing the pattern of results of the 2 (Object Type) × 2 (Cue Type) repeated-measures design for low- and high-need participants separately, while retaining all observations in the analysis.

For low-need participants, there was merely a main effect for Cue Type, $F(1, 51) = 16.40, p < .01$, $\eta_p^2 = .24$. These participants were slower to restart their behaviour after a no-go cue ($M = 527$; $SD = 58$) than after a go cue ($M = 486$; $SD = 58$), but the interaction with Object Type was not reliable, $F(1, 51) = 1.61$, $p = .21$, $\eta_p^2 = .033$. Thus, presentation of no-go cues slowed restarting of behaviour compared to go cues, and this slow down was independent of Object Type (see Table 1).

In contrast, for relatively high-need participants, besides the main effect for Cue Type, $F(1, 51) = 28.47, p < .01$, $\eta_p^2 = .36$, the interaction between Object Type and Cue Type was reliable, $F(1, 51) = 4.74, p < .05$, $\eta_p^2 = .09$. Consistent with our expectations, simple effect analyses revealed that high-need participants were reliably slower to restart when a glass of water had been paired with a no-go cue than when a control object had been paired with a no-go cue, $F(1, 51) = 5.51$, $p < .05$, $\eta^2 = .10$ (see Table 1). Finally, for high-need participants there was no

Table 1. *Mean reaction times on restart trials per trial type as a function of need for water*

	Go cue		*No-go cue*	
	Control	*Water*	*Control*	*Water*
Low need	482 (62)	490 (63)	536 (70)	518 (64)
High need	507 (62)	498 (63)	547 (70)	574 (64)

Note: Standard deviations are in parentheses.

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[1] Analyses are also reliable with cut-offs of 200 and 250 ms.

reliable difference in reaction times when a glass of water had been paired with a go cue compared to when a control object had been paired with a go cue, $F < 1$.

DISCUSSION

Incidental presentation of glasses of water, together with no-go cues, caused slower subsequent restarting of behaviour compared to when no-go cues were presented over control objects, but only for relatively high-need participants. This finding suggests that withholding responses after incidental perception of need-rewarding (positive) objects involves motor inhibition of unintentional prepared impulses by the rewarding objects. This motor inhibition puts a brake on the motor system (e.g., Aron, 2007; Coxon et al., 2006), and slows down responding to subsequently presented action probes.

An important question raised by the present findings is whether the rewarding objects in thirsty participants unintentionally prepared motor action to the objects, or increased preparation of the task specific go responses. This latter possibility may be considered for two reasons. First, one could argue that the go responses might have been perceived as approach responses, and hence were prepared by the rewarding objects (e.g., Chen & Bargh, 1999). With regard to this question it is important to note that evidence is accumulating that the motivational meaning of specific responses (such as pressing a key) depends on context (Aarts & Veling, 2009; Bamford & Ward, 2008; Eder & Rothermund, 2008), and there is reason to believe that go responses are not perceived as approach responses by default in go/no-go tasks. For instance, Wentura, Rothermund, and Bak (2000) increased the size of objects after responding in a go/no-go task (i.e., creating the illusion that the objects were coming closer to the participants) to ensure that key presses to these objects were represented as approach responses. Because responses in the current task did not lead to a decrease in distance to the objects we do not think the responses in the current task can be considered approach responses.

Second, one could also consider our data in the perspective of stimulus–response (in)compatibility. Specifically, it may be that the go response option was coded as a positively valenced response option, which would result in congruency between the valence of the (positive) rewarding objects and the go responses. As a result of positive coding, incidental perception of rewarding objects may have prepared go responses, which were inhibited by the no-go cues. According to this explanation, then, rewarding objects may not have increased preparation of responses to the objects, but may have prepared positive go responses. Previous work has shown, however, that repeatedly associating neutral objects with either go or no-go responses in a go/no-go task does not result in differences in evaluations between these objects (Veling et al., 2008), suggesting that the go and no-go responses do not have affective codes per se.

Furthermore, it is important to point out that both alternative views outlined above would also predict a facilitation effect on restart trials preceded by rewarding objects and go cues, which we did not find. Although this null effect should be treated with caution, as it may also be the result of other factors (e.g., a ceiling effect of action preparation after presentation of go cues), the absence of a facilitation effect does not support the notion that the rewarding objects increased preparation of task-specific go responses. Nonetheless, to further rule out the possibility that the current effects are driven by the nature of the task-specific go responses (i.e., key presses) it would be worthwhile to manipulate the nature (e.g., spatial direction) of the task-specific go responses (e.g., performing either an approach or withdrawal movement as a go response). When the observed inhibition after a no-go cue is indeed directed at the unintentional preparation of motor action to the rewarding objects, and is not dependent on the nature of the task-specific go responses, strength of the motor inhibition should be independent of the nature of the task-specific go responses.

Accordingly, we propose that the rewarding objects unintentionally (though covertly) prepared action in the motor system, which was inhibited after presentation of no-go cues. Because we measured the preparation of responses by rewarding objects via an indirect measurement procedure (i.e., motor inhibition of the prepared responses) we cannot draw strong conclusions concerning the nature (e.g., spatial direction) of the type of responses that were prepared. However, as the rewarding property of an object, almost by definition, motivates an individual to obtain this object (e.g., Schultz, 2006) we think it is likely that perception of such objects unintentionally activates motor programmes that are instrumental in obtaining these objects. These responses could represent motivational approach responses (e.g., Chen & Bargh, 1999; Krieglmeyer et al., 2010), well-learned habitual responses (e.g., Aarts & Dijksterhuis, 2000), or contextually primed responses (e.g., Custers & Aarts, 2010) that share the property of increasing the likelihood of getting the object. Thus, the contribution of the present work lies in revealing that rewarding objects unintentionally prepare stronger motor impulses than non-rewarding objects. Given the present suggestion that the nature (e.g., spatial direction) of these unintentionally prepared impulses do not matter, and the ongoing debate about whether positive objects evoke some specific responses (e.g., approach movements) more strongly than others (e.g., withdrawal movements; e.g., Eder & Rothermund, 2008; Krieglmeyer et al., 2010), it would be interesting to further explore which types of responses are impulsively evoked and sensitive to inhibition by no-go cues.

Finally, it is worth noting that the observed increase in action preparation may have been caused by arousal rather than the positive valence of the rewarding objects. One way to disentangle this issue is to present arousing negative objects in the present task. Interestingly, previous research that examined effects of incidental presentation of negative objects has observed inhibition of the motor system (i.e., as in freezing; e.g., Wilkowski & Robinson, 2006). It has been proposed that acting in the context of negative objects, instead of directly responding to negative objects, causes initial inhibition of the motor system to avoid detection by predators (Fanselow, 1994). Hence, presenting negative objects in the present task may result in an overall slow down in responding compared to the neutral objects, i.e., irrespective of the go and no-go cues. This result would suggest that the present effects are specific for positive (rewarding) objects, and concurs well with theories that distinguish between a behavioural inhibition system that is sensitive for threat cues and puts behaviour on hold, and a behavioural activation system that is sensitive for the presence of rewards and governs the engagement of action (see Amodio, Master, Yee, & Taylor, 2008).

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